VOLUME 24
JULY 1, 1982 - June 30, 1983
FEDERAL AID IN FISH RESTORATION
AND
ANADROMOUS FISH STUDIES

A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

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STATE OF ALASKA

Bill Sheffield, Governor

Annual Performance Report for

ESTABLISHMENT OF GUIDELINES FOR PROTECTION OF THE SPORT FISH RESOURCES DURING LAND USE ACTIVITIES

by

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Volume 24 Study No. D-I

RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish Investigation of Alaska

Project No.: F-9-15

Study No.: D-I

Study Title: A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

Job No.: D-I-A&B

Job Title: Establishment of Guidelines for Protection of the Sport Fish Resources During Land Use Activities

Cooperators: S. T. Elliott and D. J. Hubartt

Period Covered: July 1, 1982 to June 30, 1983

ABSTRACT

Over the past decade, many investigators have described how clearcut logging can affect stream environments, but the status of juvenile salmonid populations in clearcut logged watersheds is still poorly understood. Recently, Murphy and Hall (1981) and Murphy et al. (1981) demonstrated that clearcut streams often had a higher biomass of salmonids than non-clearcut.

We examined stream habitat and populations of juvenile coho salmon (Oncorhynchus kisutch) and Dolly Varden char (Salvelinus malma) in nine tributaries that had been clearcut logged in the 1960's and nine tributaries in undisturbed watersheds and found no significant difference (P#0.05) in biomass of salmonids in logged and non-logged streams. The stream habitat differed in logged streams and had fewer undercut banks and greater amounts of small debris. Regression models indicated that both species of salmonids utilize different types of habitat in logged streams as opposed to non-logged.

These results are preliminary pending further analysis.

KEYWORDS

Clearcut logging, biomass, Dolly Varden char, Salvelinus malma (Walbaum), coho salmon, Oncorhynchus kisutch (Walbaum), habitat, modeling.

BACKGROUND

The Tongass National Forest, which occupies most of southeastern Alaska, is rich in timber, mineral, and fishery resources. Harvest of the timber resource, which accelerated in the 1960's in response to two 50-year contracts sold to Alaska Lumber and Pulp and the Ketchikan Pulp Co. (now Louisiana Pacific Ketchikan), often occurred to the detriment of fisheries. In recognition of this increasing problem, the Division of Sport Fish of the Alaska Department of Fish and Game created the Land Use Project in 1970 with a mission to survey logging-fishing problems, conduct research, and design and provide guidelines that minimize the impact of logging on fisheries.

The Land Use Project surveyed logged watersheds in 1971 and found that many logging practices were affecting fish populations (Reed and Elliott, 1972). These observations, together with guidelines to minimize this impact, were published as a pamphlet in cooperation with the U. S. Forest Service (Sheridan, et al., 1976) and became the basis for the best management practices in use today. The surveys also showed that logging debris in salmonid nursery streams was a wide spread problem that deserved further investigation. A research project was begun at Starrigavan Creek in 1973 to investigate the impact of debris removal on salmonids. This program was completed in 1981 and the results and recommendations are now ready for publication in an appropriate fisheries journal.

Between 1973 and 1979, the project was actively involved with the U.S. Forest Service in planning timber harvest so as to provide the least impact on fishery resources (Reed and Elliott, 1973; Reed, 1974; Dinneford, 1975; Dinneford, 1976; Hubartt, 1977). This was accomplished "on the ground" through the Forest Service's Interdisciplinary Team program and through participation in two planning efforts, the "Southeast Alaska Area Guide" (Anon, 1977) and the "Tongass Land Management Plan" (Anon, 1979). The project's involvement in the Tongass Guide formally introduced and strengthened guidelines for protection of fish resources. The project also played a key role in the Tongass Land Management Plan and was successful in acquiring protective classification for many of southeastern Alaska's best fisheries producers (Hubartt, 1978).

The work of the Land Use Project has not been limited solely to timber harvest problems. The announcement by U.S. Borax and Chemical Company in 1976 of their proposed open pit molybdenum mine between the Keta and Blossom Rivers caused considerable concern among fishermen and biologists for the future of fishery resources in those watersheds. In response, the Land Use project spent two seasons at the Keta River gathering data on salmonid standing crop and macro-invertebrate populations that would serve as future baseline data for environmental monitoring of the Borax project (Elliott, 1980).

By 1979, it was clear that major questions on the impact of timber harvest on fisheries had not been answered. Chief among these was:

Does removal of streamside vegetation during clearcutting affected the summer standing crop and overwinter survival of salmonidsΣ

Consequently, from 1979 through 1981, the project refined its population estimate techniques, developed methods of measuring various habitat parameters, and greatly improved its analytical capabilities by using the University of Alaska Computer Network (Hubartt, 1979; Hubartt, 1980; Hubartt, 1981; Elliott, 1982). Thus prepared, the project initiated a detailed study of salmonid (Table 1) standing crop and stream habitat in logged and unlogged nursery streams to determine if timber harvest resulted in changes in production. The preliminary findings of that study is the subject of this report.

RECOMMENDATIONS

Management

Salmonids appear to be flexible enough in their habitat requirements to adapt to new stream environments within the first 20 years after clearcutting. However, the strong affinities of salmonids for debris-formed pools and bank habitat shown in this analysis reiterate our concerns for the long term value of large debris and stream side root systems.

The natural process of decay and weathering of large debris and streamside root systems will occur without replacement in the managed forest. Consequently, the outlook for salmonid production 50 years hence in watersheds that were harvested between 1960 and 1980 is not good.

In past years, the U.S. Forest Service, in close cooperation with the Land Use Project and the State of Alaska, has created guidelines to protect fish habitat form immediate and observable impacts from timber harvest. Now a new element, TIME, must be considered if fish production is to be maintained at its current level. This will require new ways to thinking about fish habitat and a novel approach to the creation of future guidelines.

Research

Research in Alaska on winter environments and overwinter survival in clearcut drainages has been identified by researchers as one of high priority. Concerns for winter survival go beyond the effects of temperature and icing. and involves the contribution of bank habitat (Bustard and Narver, 1975) to the survival of juvenile coho. Our findings show that bank habitat occurs less frequently in logged watersheds, a factor which could limit the overwinter survival.

We propose to monitor 20 watersheds to determine if differences in survival rate occur in logged and unlogged streams during the winter of 1983-1984. We will also examine habitat parameters with bearing on survival and monitor temperatures, ice thickness, and snow depth.

OBJECTIVES

1. Determine if there are differences in the standing crop and biomas (no. and gms/ms^2) of juvenile Dolly Varden char and coho salmon in logged and unlogged nursery streams.

Table 1. List of common names, scientific names, and abbreviations.

Common Names	Scientific Name and Author	Abbreviation
Coho Salmon	Oncorhynchus kisutch (Walbaum)	SS
Dolly Varden	Salvelinus malma (Walbaum)	DV

2. Determine if there are differences in the winter survival of juvenile Dolly Varden char and coho salmon in logged and unlogged nursery streams.

TECHNIQUES USED

Hypothesis

To further clarify the objectives of this study, we defined and tested three hypotheses. Because of the poor understanding of the effects of timber harvest on salmonid production, the three hypotheses are two-tailed and test only for differences and do not imply that clearcutting decreases or increases standing crop or survival. Specifically the hypotheses are:

1. Timber harvest along the banks of salmonid nursery streams will affect juvenile salmonid standing crop. This effect will be most pronounced in older clearcuts under the assumption that they represent a "worse case situation" and are most likely to illustrate any differences.

2. Clearcutting to the banks of salmonid nursery streams changes the winter temperature regimes of small streams.

3. Clearcutting to the banks of salmonid nursery streams changes the rate of winter survival of juvenile salmonids.

Selection of Study Sites

The population of streams chosen for this study was distributed on Baranof and Chichagof Islands, primarily around the Sitka vicinity, Peril Straits, and Tenakee Inlet. For logged sites, we chose watersheds that had been logged between 1960-1970 and that had clearcuts of sufficient size that could encompass a tributary of 300 meters in length. Using random methods, we selected about 50 drainages and surveyed each for suitable study areas using the following criteria:

1. The stream must have 300 meters of fish habitat contained totally within a clearcut or old growth forest.

2. Must be a 2nd or 3rd order stream with an average width of not greater than 3 meters.

3. If it is a tributary, the study reach should be located as close to the confluence as possible.

4. High gradient streams should be avoided.

5. Logged and unlogged sites should be in close proximity to decrease the variation in land form and stream morphology. The goal of this criteria was to create a set of 10 pairs of streams, a logged and unlogged stream in each pair that share similar physical attributes.

Stream selections and surveys were complete by June 30 and yielded the streams listed in Table 2 (also see Figure 1 of the appendix).

Table 2. Twenty non-logged and logged study sites in southeastern Alaska arranged in pairs by proximity and date of sample.

Pair No.	Non-Logged Sites	Dates Sampled	Logged Sites	Date Sampled
1	"Slick Cr." (trib. to 112-45-036)	7/23-7/26	"Seal Bay Cr."(trib. to 112-46-009)	7/29-8/01
2	"Kadashan" (trib. to 112-42-025)	7/08-7/10	"Fog Cr." (trib. to 112-42-032)	7/15-7/18
3	"Catherine I."(trib. to 112-11-050)	6/08-6/09, 6/29	"Lazybear Cr." (113-59-000)	9/25-9/28
4	"Sagan Cr." (trib. to 112-11-012)	7/16-7/19	"Deadcat Cr." (trib. to 113-51-004)	7/21 7/24
5	"Girdle Cr." (trib. to 113-54-007)	8/10-8/13	"Nofish Cr." (trib. to 113-57-005)	8/04-8/08
6	"Steep Cr." (113-41-041)	8/19-8/22	"Noah Cr." (111-66-005)	8/26-8/29
7	"Honda Cr." (trib. to 113-45-006)	8/09-8/12	"Kawasaki Cr."(trib. to 113-42-006)	8/13-8/17
8	"Narrow Bay U"(trib. to 113-42-001)	7/27-7/30, 8/04	"Narrow Bay L"(trib. to 113-42-001)	7/28-7/30 8/04-8/05
9	"Halleck Falls" (113-42-007)	8/21-8/23 9/03-9/10	"Halleck 04" (113-42-004)	9/11-9/12
10	"Indian River"(trib. to 113-41-019)	7/13-7/17	"Remains Cr." (trib. to 113-41-015)	7/19-7/22

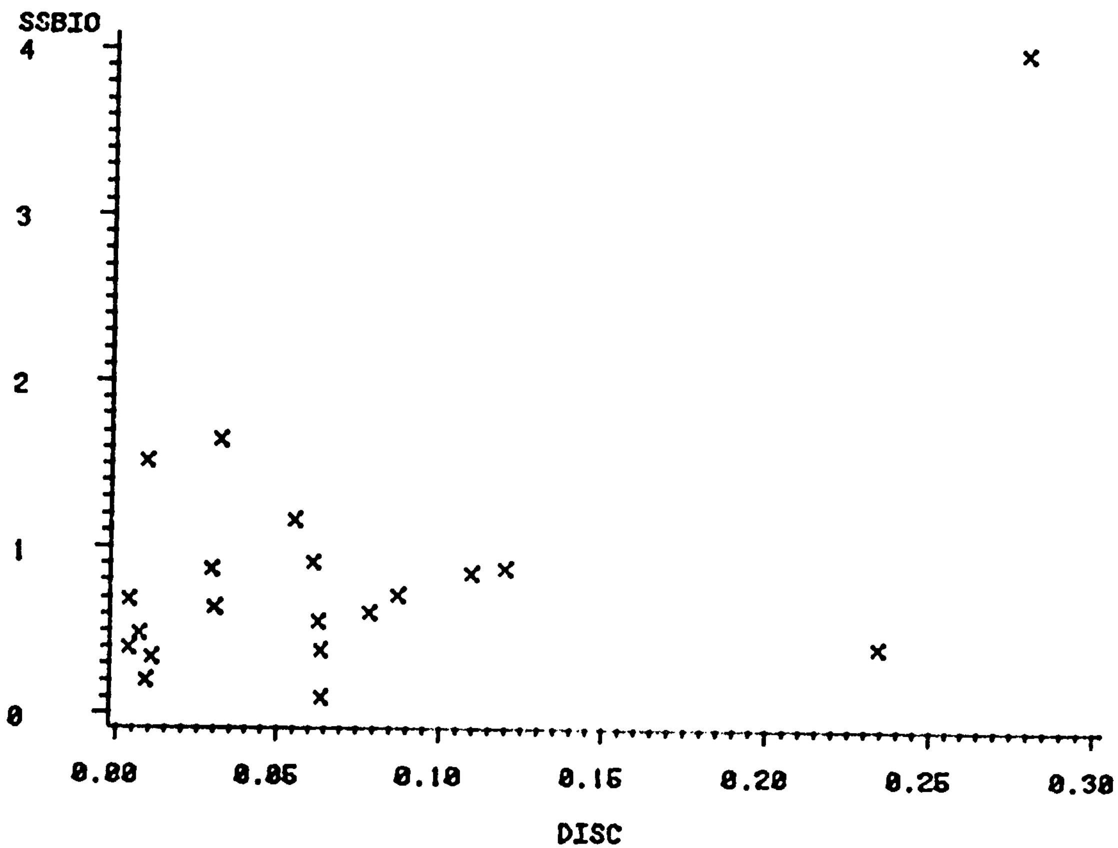

Figure 1. Scatter plot of juvenile coho biomass (SSBIO) vs stream discharge showing two outliers Halleck Falls and Kawasaki Creek.

Population Estimates and Sampling

At each study site, the downstream end of the 300-meter reach was located by random method and marked. Ten study sections, each 30 meters in length, were established and marked within the boundaries of the reach. We had calculated, based on 1981 data, that seven sample sections would closely approximate ($P<0.05$) the population density of juveniles in the ten sections, as well as provide an adequate number of fish that could be killed for age-length-weight and food analysis. Consequently, we chose seven out of the ten 30-meter sections using a random number device for intensive sampling.

Population estimates were performed on each section using Chapman's modifications of the Peterson method. "Gees" wire mesh minnow traps baited with boraxed salmon roe were used to capture fish for both the marking and recapture period. Traps were chosen as capture devices because of the poor performance of electro-fishing gear or seine nets in waters that are low in conductivity and heavily laden with woody debris.

Each 30-meter section was blocked at the downstream and upstream ends using 0.25 inch mesh nets and weighed down with stones and gravel to make them as "fish tight" as possible. Once the nets were in place, 15-20 baited traps were distributed within the section and placed in all areas thought to be suitable as fish habitat. This resulted in a trap density of about 1 trap every 3 meters. "Saturation trapping" of this type is necessary because previous studies have shown that low trap density increases the risk of creating cohorts of fish that are not influenced by the traps. This violates one of the conditions of the Peterson method concerning equal probability of capture. To determine catch rates, the time at which each trap was set was recorded and the type of habitat which the trap fished was recorded.

The traps were left undisturbed for two hours and, beginning with the downstream trap, the traps were removed, the time recorded, and the fish were identified, measured, and marked by removing the tip of the upper or lower caudal lobe, and released in the area in which they were captured. We chose not to tranquilize fish as it allowed quicker processing of fish, minimized handling, and the fish recovered faster once returned to the stream.

We worked only with fish that ranged in size between 55 and 150 mm to avoid working with fry. This was done because fry are highly transient in terms of migration and they also experience high rates of natural mortality that could skew population statistics collected between the time the study began and ended. Furthermore, we have experienced high mortality rates of fry as a result of handling and clipping, predation of fry by larger fish inside the traps, and high rates of escape through the mesh and entrances of the traps. Since we were interested in the relationship of juveniles to their habitat, parrs represent a more stable class of fish that are a better descriptor of carrying capacity and the quality of habitat.

Once the fish were returned to the section, they were left undisturbed overnight to adjust to trauma and redistribute themselves. The following day freshly baited traps were set again in the same areas and, after waiting two hours, were removed and the catch was examined for marks. Fish were taken for samples at this time, with the sampling continuing in each section until the desired number of 50 coho and 50 Dolly Varden were collected.

Immediately after the fish were killed, the samples were identified, measured to the nearest 1 mm fork length, and weighed to the nearest 0.1 g with a Pesola spring scale. Both otoliths were extracted and the stomach, from the pylorus to the intestine, was removed and preserved in a shell vial containing 70% ethanol. Scales were taken from juvenile coho as an aid in aging.

Measurement of Habitat Features

Estimates of the numbers of fish and their biomass alone are insufficient to describe how clearcutting may have affected some streams. The collection of detailed information on habitat is necessary for three reasons: 1) to take into account the influence of habitat components on fish population size in undisturbed streams so as to isolate and identify any effects that occur in the logged streams; 2) there is a continuing need for more data on stream factors that are associated with salmonid production to improve the quality of predictive models; and 3) evaluate the accuracy of predictive models developed by Barber et al. (1981), now being used by the U.S. Forest Service.

Stream habitat was grouped into the following general categories; 1) depth-velocity characters, 2) dimensional characters, 3) terrestrial influences, and 4) substrate size and composition. It is recognized that these categories are not independent and that intercorrelation exists among them.

Depth-Velocity Characters:

Each section was divided into subunits called partitions that became the basic unit of measurement of habitat types. A partition was composed of one type of habitat and could be a riffle, a pool, or glide and they are delineated from one another based on depth and velocity. Partitions can be of any shape, such as six or seven sided geometric figures, but for simplicity we limited the number of sides that could be measured to four of any length. The area of each partition was solved using the formulas for an oblique triangle or quadrangle as follows:

Formula for quadrangle:

$$S = (A+B+C+D)/2$$

$$\text{Area} = [(S-A)(S-B)(S-C)(S-D)]^{\frac{1}{2}}$$

where A, B, C, D are sides of the quadrangle

Formula for oblique triangle:

$$S = (a+b+c)/2$$

$$\text{Area} = [(S(S-a)(S-b)(S-c)]^{\frac{1}{2}}$$

Partitions were described using the classification scheme developed by Bisson (1981) and are found in Table 3.

Discharge was taken at the downstream end of each of the seven sections by measuring the width of the surface and measuring the depth at 1/4, 1/2, and 3/4 distances across a transect. Velocities were then taken at each of the three locations using the float technique which we found to be superior to mechanical current meters in small streams. Three trials were conducted at each depth point to assure accuracy. The depth and velocity values were substituted into the following equation to obtain discharge:

$$\text{Discharge} = \frac{(^{D}\,1/4 + {}^{D}\,1/2 + {}^{D}\,3/4)}{4} \times \frac{(^{V}\,1/4 + {}^{V}\,1/2 + {}^{V}\,3/4)}{3}\,(W)\,(a)$$

D = depth at 3 locations, e.g., 1/4, 1/2, 3/4 distance across transect

V = velocity at 3 locations

W = width of stream at the transect

a = 0.8 if stony bottom; 0.9 if bottom is clay, bedrock, sand, or mud

Gradient for each section was determined using a carpenters line level on a 40 meter string. The string was fixed at the upper end of the section and the distance from the leveled string to the water surface was measured to the nearest 0.01 meter at both ends of the section. Gradient was calculated by subtracting the two distances to obtain the difference and dividing by 30 to express the drop in stream height in terms of stream run and convert to percent.

Dimensional Characteristics:

We measured two dimensional characters at each section, surface area and pool volume. Surface area was obtained by summing the areas of all the partitions within a section. Pool volume, found to be highly correlated with coho standing crop (Nickelson et al., 1979) was obtained by multiplying mean depth of a pool by its area as follows: depths were taken at 1/4, 1/2, 3/4 distance along a transect across the middle of the pool and perpendicular to the channel. Mean depth was multiplied by the partition area to obtain volume.

Terrestrial Influences:

This set of parameters involved the influence of the forest, in particular debris contribution and its relationship to mid-stream habitat, bank structures such as undercut banks, overhanging riparian vegetation, stability rating of the stream banks, and the type and amount of canopy shading.

Table 3. Habitat types used to describe partitions in sections (adopted from Bisson, 1981).

1. Riffles (3 types)

   a) riffles = low gradient; surface turbulence

   b) rapids = riffles with white water and exposed rocks; higher gradient

   c) cascade = verticle drops with small plunge pools

2. Glides (1 type)

   No surface turbulance; often found at tail of pools.

3. Pools (7 types)

   a) backwater pool = on margin of stream; have eddies

   b) plunge pools = formed by scour action of downward plunging water

   c) upsurge pools = similar to plunge but scoured in upward motion; usually deflected upward by subsurface log

   d) lateral scour pools = often at bends in stream; scour occurs in horizontal plane

   e) trench pool = groove in bedrock

   f) dammed pool = large debris jams

   g) secondary channel pool = highwater remnant

Forest debris was of two types, small material with a diameter of less than 10 cm and large material having a diameter of greater than 10 cm. Small debris, such as twigs, branches, etc., usually occurred in mats and were each measured by taking the length and width and calculating its surface area and determining whether it was suspended over the water surface or in contact with the surface. Large debris, usually logs and root systems, was measured volumetricly by taking the length and diameter and calculating the volume using the formula for a cylinder.

Large debris is an important component of stream habitat, especially in the formation of pools. We determined the contribution of debris by noting the number of times that large debris was the causitive agent of pool formation and expressed it as percent frequency of occurrence.

To evaluate bank habitat, we measured the total linear distance of undercut banks along both banks of the section to the nearest 0.1 meter. The criteria for defining undercuts was if it was judged to be capable of sheltering fish. No attempts were made to measure the area of the overhang. Each undercut bank was examined to see if it was supported by tree root systems and the presence or absence of such was noted. Root systems were classed as either coniferous or deciduous.

Overhanging riparian vegetation was measured by attaining the length and width (overhang from bank) of herbacious vegetation along both banks and expressing as m^2.

We also evaluated the stability of the stream banks using the U.S. forest Service's system entitled "Stream Reach Inventory and Channel Stability Evaluation".

Overhead canopy cover was measured by inspection with a 2" length of PVC tubing 1" in diameter. Percent canopy cover was measured to the nearest 10% at three randomly located points and averaged.

Substrate:

The substrate composition was measured by noting the substrate size and embeddedness (Bjorn et al., 1977) within the perimeter of each partition (Table 4). The area of each substrate class was summed to obtain the composition of various substrate types for the section.

Water Quality

Water quality data were collected from all 20 sites during 1 day's time, between 09:00-17:15. No precipitation occurred that day that could cause variable effects between the time sampling began and ended and all streams were in low flow condition. We measured the following parameters: specific conductance, pH, calcium hardness, total hardness, alkalinity, D.O., and temperature.

Studies of Overwinter Survival

We began studies of overwinter survival by first examining the temperature regimes of the 10 logged and 10 unlogged sites. Differences in temperature

Table 4. Ranking scheme used to classify streambottom substrates and cobble embeddedness, (adapted from Bjornn, et.al, 1977).

Rank	Substrate Classification Substrate Size	
1	organic debris	
2	< 1.58 mm	(< 0.06 inches)
3	1.58 to 6.35 mm	(0.06 to 0.25 inches)
4	6.35 to 25.4 mm	(0.25 to 1.00 inches)
5	24.50 to 63.50 mm	(1.00 to 2.50 inches)
6	63.50 to 127.00 mm	(2.50 to 5.00 inches)
7	127.00 to 254.00 mm	(5.00 to 10.00 inches)
8	>254.00 mm	(>10.00 inches)

between the logged and unlogged sites is a pre-condition to future studies on survival and, consequently, only temperature was studied during the winter of 1982-1983.

We deployed a Ryan J-180 recording thermograph to measure water temperature and a Ryan K-90 thermograph for air temperature at each site. The K-90 thermographs were sealed in a water tight containers and affixed to trees over the bank of the stream. The instruments were installed on November 11, 1982 and will be removed in May 1983. The charts from each will be read and analyzed in May and the results reported in the FY 84 Annual Performance Report.

Statistical Design

Logged and Unlogged Standing Crop:

Data were collected in a way so that it could be analyzed by a specific statistical design. Emphasis was placed on testing significant differences between the two groups of streams, i.e., logged and unlogged by using t-tests and analysis of variance. Since habitat was expected to influence the means of standing crop within each groups, a true test of means could not be conducted without taking into account the differences in habitat.

By using analysis of covariance, the within-group effects of habitat can be overcome. The method adjusts the standing crop in each group based on the influence of habitat and then uses analysis of variance to test the difference in the adjusted means of logged and unlogged groups.

We were also interested in learning more about the relationship of salmonids to their habitat. To develop predictive models relating standing crop to habitat, we used stepwise regression analysis and best subset regression analysis to construct models for logged and unlogged groups and all streams together.

In addition to tests between group means, we also conducted paired t-tests. Streams were selected and sampled in a manner so that pairs composed of logged and unlogged streams could be analyzed. We also conducted t-tests on matched pairs of streams based on their rank as defined by gradient, discharge, and surface area. We recognize that these latter groups of pairs are not paired observations as defined by the test criteria; our intent in these tests was to reduce the variance attributable to these parameters.

To determine if there were differences in stream habitat in logged and unlogged groups, we subjected the stream's variables to discriminant analysis, a procedure which describes a set of parameters that are most distinguished between the two groups.

All analysis was performed either on the University of Alaska computer network, using the BMDP statistical package (Dixon et al., 1981), or on the State of Alaska computer system, using the SAS programs (SAS Institute, Inc., 1982).

A list of all variables, their abbreviations, and units of measurement may be found in Table 5.

FINDINGS

Water Quality

Data on water chemistry from the 20 study areas showed that there was very little difference between the logged and unlogged groups of streams (Table 6). This was also confirmed by using t-tests ($P<0.05$); the results of which are found in Table 6. All the streams were low in nutrients and in specific conductivity, with the exception of Seal Bay, Slick Creek, and Halleck 04.

Data Evaluation

Examination of the distribution of data showed that two streams, Halleck (unlogged) and Kawasaki Creek (logged) were extreme outliers relative to the data field (Figure 1). We removed this data from the analysis, reducing the total sample size to 18, with the beneficial result of improving the correlation of habitat parameters with fish parameters.

Stream Habitat

There was little difference ($P<0.05$) between the mean values of the 54 habitats and water quality parameters examined in the 10 logged and 10 unlogged streams (Table 7). Only three habitat components were significantly different: the frequency of coniferous root systems, the frequency of deciduous root systems (mostly alder) as support structures for undercut banks, and the area of suspended debris less than 10 cm, i.e., slash.

To determine if variables, when grouped together (a comparison of the "entire environment" in logged and unlogged streams), were significantly different, we examined the test for Hotelling T square using the following variables: total area, gradient, discharge, undercut banks, total volume of pools, overhead cover, the four categories of debris, riparian vegetation, and bank stability index. This test showed that the environments composed of these habitat parameters were not significantly different ($P<0.05$) in logged and unlogged streams.

Discriminant analysis (Table 8) shows that four variables (discharge, area of small suspended debris, amount of undercut banks, and gradient) were the most significant in distinguishing the nine logged from the nine unlogged streams.

Relationship of Salmonids to Stream Habitat

Multiple regression models were constructed using the dependent variables coho biomass, Dolly Varden biomass, and salmonid biomass in logged and unlogged streams, and for all streams combined. Three sets of regression models are presented; the first contains 24 habitat variables, while the second contains the date of sampling and removes FDR, FCR, and FDP

Table 5. List of variables used in the analysis of 10 logged and 10 unlogged study streams.

Variable Abbreviation	Definition	Units
Fish Variables:		
BDV	Calculated biomass of juvenile Dolly Varden	g/m^2
BSS	Calculated biomass of juvenile coho salmon µ 55 mm	g/m^2
B	Calculated biomass of Dolly Varden and coho salmon	g/m^2
DDV	Density of juvenile Dolly Varden	$No./m^2$
DSS	Density of juvenile coho salmon µ 55 mm	$No./m^2$
D	Density of Dolly Varden and coho salmon	$No./m^2$
CPDV	Catch per unit-effort of Dolly Varden	No./trap-hr.
CPSS	Catch per unit-effort of coho salmon	No./trap-hr.
CP	Catch per unit-effort of both species	No./trap-hr.
TDV	Total catch of Dolly Varden (M+C-R)	No.
TSS	Total catch of coho (M+C-R)	No.
WDV	Average weight of Dolly Varden	g
WSS	Average weight of coho	g
FLDV	Average fork length of Dolly Varden	mm
FLSS	Average fork length of coho	mm
Habitat Variables:		
TAREA	Total area of stream section	m^2
ARIF	Area of riffles	m^2
ARAP	Area of rapids	m^2
ACAS	Area of cascades	m^2
AGLI	Area of glides	m^2
VP	Total volume of pools	m^3
VBAC	Volume of backwater pools	m^3
VPLU	Volume of plunge pools	m^3
VUPS	Volume of upsurge pools	m^3
VLAT	Volume of lateral scour pools	m^3
VTRE	Volume of trench pools	m^3
VDAM	Volume of dammed pools	m^3
VSEC	Volume of secondary pools	m^3
VSU	Volume of large (>10 cm) suspended debris	m^3
VUS	Volume of large (>10 cm) submerged debris	m^3
ASU	Area of small (<10 cm) suspended debris	m^2
AUS	Area of small (<10 cm) submerged debris	m^2
ARV	Area of riparian vegetation (both banks)	m^2
DUB	Length of undercut banks (both banks)	m
IO	Percent of overhead canopy cover	%
GR	Percent gradient	%
DISC	Discharge	m^3/sec
DEP	Average depth	cm
VEL	Average velocity	cm/sec
WID	Average width	cm

Table 5. (Cont'd) List of variable used in the analysis of 10 logged and 10 unlogged study streams.

Variable Abbreviation	Definition	Units
FDR	Percent frequency of deciduous root systems associated with undercut banks	%
FCR	Percent frequency of coniferous root systems associated with undercut banks	%
FDP	Percent frequency of debris-formed pools	%
IX	Stability Index	none
Substrate Classification:		
AA	Area of organic debris	m^2
BB	Area of substrate <1.58 mm	m^2
CC	Area of substrate from 1.58 to 6.35 mm	m^2
DD	Area of substrate from 6.35 to 25.4 mm	m^2
EE	Area of substrate from 25.4 to 63.5 mm	m^2
FF	Area of substrate from 63.5 to 127.0 mm	m^2
GG	Area of substrate from 127.0 to 254.0 mm	m^2
HH	Area of substrate > 254.0 mm	m^2
Water Quality Variables:		
DO	Dissolved O_2	mg/L.
TEMP	Water temperature	°C
COND	Conductivity	µmho
HARD	Total hardness	mg/L.
CAL	Calcium hardness	mg/L.
ALK	Alkalinity	mg/L.
PH	pH	...

Table 6. Water quality of 20 logged and non-logged sites obtained between 09:00-17:15 on 9/21/82. Condition: zero precipitation and low flows.

	Status	Specific Conductance µmho	ph.	Hardness mg/L. Calcium	Hardness mg/L. Total	Alkalinity mg/L.	D.O. mg/L.	Temp. °C
No Fish	nonlogged	17	6.7	8	12	10	11	5.4
Slick	nonlogged	179	6.9	10	18	17	11	8.7
Kadashan	nonlogged	46	6.9	28	30	24	11	8.0
Catherine	nonlogged	35	6.8	12	32	21	10	8.7
Sagan	nonlogged	7	6.9	2	7	4	12	8.4
Steep	nonlogged	66	7.0	10	33	9	11	10.0
Honda	nonlogged	12	6.7	4	35	6	11	10.0
Narrow Bay U.	nonlogged	30	6.7	22	25	19	10	10.8
Halleck Falls	nonlogged	22	6.8	20	30	9	10	10.3
Indian	nonlogged	42	6.9	8	25	13	13	9.0
Seal Bay	logged	237	6.7	12	28	15	11	8.5
Fog	logged	34	7.0	20	28	17	11	9.0
Lazybear	logged	43	7.0	24	60	23	12	9.0
Deadcat	logged	22	7.2	8	28	11	11	8.4
Girdle	logged	31	6.8	14	85	19	12	9.3
Noah	logged	62	7.1	32	36	39	11	9.5
Kawasaki	logged	41	6.9	16	46	20	12	8.0
Narrow Bay L.	logged	76	6.7	42	49	43	11	9.5
Halleck 04	logged	101	6.9	78	84	56	10	9.7
Remains	logged	63	6.5	18	36	25	13	9.0
Range	nonlogged	7-179	6.7-7.0	2-28	7-35	4-24	10-13	5.4-10.8
Range	logged	22-237	6.7-7.1	8-78	28-84	11-56	10-13	8.4- 9.7

Table 7. Comparison of 44 habitat parameters of logged and unlogged streams; 10 clearcut, 10 uncut.

	Clearcut		Uncut		t-Test
Parameter	Mean	S.D.	Mean	S.D.	$P > {}^2t^2$
TAREA	683.280	236.655	546.300	254.641	0.22
ARIF	376.730	203.805	208.200	180.709	0.06
ARAP	25.120	33.718	29.360	59.036	0.84
ACAS	2.180	4.933	4.230	9.144	0.54
AGLI	80.670	84.691	108.890	125.625	0.56
VP	41.278	21.484	46.860	33.311	0.66
VSU	8.680	12.170	5.869	5.212	0.51
VUS	28.409	19.558	32.274	56.855	0.84
ASU	13.100	10.218	4.880	4.904	0.03
AUS	52.600	27.540	40.190	24.407	0.30
ARV	164.990	115.752	122.700	90.719	0.37
DUB	78.710	57.808	133.700	86.494	0.11
VBAC	5.274	4.686	11.947	21.761	0.36
VPLU	9.360	11.151	6.602	6.886	0.51
VUPS	2.360	3.679	4.411	6.552	0.40
VLAT	14.050	13.410	17.345	20.998	0.68
VTRE	3.339	5.671	4.665	14.752	0.79
VDAM	5.747	15.694	1.132	1.283	0.37
VSEC	1.148	1.988	0.758	0.939	0.58
AA	6.400	13.246	50.700	99.977	0.19
BB	18.510	38.634	36.790	50.328	0.37
CC	35.930	28.522	46.450	82.290	0.70
DD	51.100	55.175	64.970	56.548	0.58
EE	204.660	173.785	107.430	116.174	0.16
FF	217.570	203.583	141.020	138.790	0.34
GG	106.490	129.269	54.400	86.599	0.30
HH	42.630	87.387	44.630	98.486	0.96
DO	11.400	0.843	11.000	0.943	0.33
TEMP	9.050	0.655	8.870	1.493	0.73
COND	63.100	63.733	53.500	52.135	0.71
HARD	42.600	18.374	32.600	19.461	0.25
CAL	20.600	10.024	19.200	21.852	0.85
ALK	22.200	11.235	18.100	14.907	0.49
PH	6.875	0.218	6.860	0.097	0.84
IO	45.418	32.499	44.026	19.075	0.90
GR	2.148	1.321	2.071	2.062	0.92
DEP	11.421	3.757	10.373	3.765	0.54
VEL	26.698	10.972	18.800	9.829	0.10
WID	268.493	134.390	196.232	103.474	0.19
FDR	37.359	23.037	14.167	14.057	0.01
FCR	30.498	28.116	61.283	27.404	0.02
FDP	62.297	22.175	57.570	21.010	0.63
IX	68.970	7.072	63.786	7.021	0.11
DISC	0.08696	0.0766	0.0476	0.0630	0.24

Table 8. Discriminant Analysis of 15 habitat variables in 9 logged and 9 unlogged streams.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

STEPWISE DISCRIMINANT ANALYSIS

18 OBSERVATIONS   15 VARIABLE(S) IN THE ANALYSIS
2 CLASS LEVELS   0 VARIABLE(S) WILL BE INCLUDED

SIGNIFICANCE LEVEL TO ENTER = 0.2500
SIGNIFICANCE LEVEL TO STAY = 0.2500

STEPWISE SELECTION: SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	NUMBER IN	PARTIAL R**2	F STATISTIC	PROB > F	WILKS' LAMBDA	PROB > LAMBDA	AVERAGE SQUARED CANONICAL CORRELATION	PROB > ASCC
1	DISC		1	0.2915	6.584	0.0207	0.70847026	0.0207	0.29152974	0.0207
2	ASU		2	0.1520	2.689	0.1219	0.60078848	0.0219	0.39921152	0.0219
3	DUB		3	0.1639	2.744	0.1199	0.50233284	0.0190	0.49766716	0.0190
4	GR		4	0.3286	6.362	0.0255	0.33726875	0.0045	0.66273125	0.0045

(frequency measurements that are highly intercorrelated with other variables), and the third relates coho percent composition to the variables used in No. 2.

Models generated using 24 variables (Table 9) show juvenile coho salmon and Dolly Varden react differently to habitat features in logged and unlogged streams. Coho biomass in logged streams was most associated with habitat having more riparian vegetation, stable stream banks, and narrow channel widths. Coho biomass in unlogged streams was highest where the canopy was sparse and stream velocity (as described by substrate size) was low to moderate. Dolly Varden biomass in logged streams was greatest in streams with frequent glides, low volume of large debris and fewer large substrates. In unlogged streams, char biomass was greatest in those streams having the least fine debris, greater quantities of large debris, and the least amounts of large substrates. Note the strong relationship of coho and Dolly Varden in many of the equations to ARV, DUB, FDR, FCR, and IX, all of which describe the amount or quality of stream bank cover.

Table 10 provides predictive equations that omit the variables FDP, FCR, and FDR. Removal of these variables resulted in changes in four equations: salmonid biomass in unlogged streams, and all three equations describing biomass in the total sample. The date of sample was included in "unlogged salmonid biomass" indicates that biomass decreased in streams sampled later in the season and could be an artifact of the order in which streams were sampled.

The other equations (combined streams) are instructive in that ARV, the area of riparian vegetation overhanging the streams, was consistently one of the better predictors of biomass, which confirms the importance of streamside cover.

The final set of models is aimed at describing species preference by regressing percent composition of coho on the habitat variables. The predictive equations of percent composition of coho (Table 11) show that this species prefers habitat with lower velocities, stable stream banks, with numerous undercuts. In clearcut streams, pool volume was the best predictor of coho composition, while in uncut streams, undercut banks was the best predictor.

Figures 2 and 3 illustrate the fit of the observed coho biomass (biomass obtained by measurement in the field) to that predicted by two repression models from Table 10. Note that both models account for 90% or more of the variation in observed biomass and that no habitat parameters are common to either model.

<u>Salmonid Biomass in Logged and Unlogged Streams</u>

Population Statistics in the Streams Sampled:

Biomass of coho and Dolly Varden showed considerable range (Table 12). In unlogged streams, coho biomass ranged from 0.10 g/m^2 to over 1.6 g/m^2 and had densities between 0.01/m^2 to 0.37/m^2. Juvenile Dolly Varden biomass in unlogged streams was 0.04 g/m^2-3.67 g/m^2, with densities of 0.03/m^2-0.8/m^2. In logged streams, the range of coho biomass was higher (0.19 g/m^2-3.9

Table 9. Predictive equations of coho, Dolly Varden, and salmonid biomass in logged and unlogged streams. (Several habitat variables have been omitted because of low frequency of occurrance; see Table 5 for explanation of variables.)

Dependant Variable = Biomass	R	R^2	Predictive Equation
Logged Streams, N=9			
Coho Biomass	0.964	0.931	Y = -4.7614 + 0.0048ARV + 0.0814IX - 0.0039WID
Dolly Varden Biomass	0.924	0.854	Y = 2.1642 + 0.0161AGLI - 0.0729VUS + 0.0044FF
Salmonid Biomass	0.959	0.921	Y = 2.7527 + 0.0182AGLI - 0.0756VUS + 0.0051FF
Unlogged Streams, N=9			
Coho Biomass	0.946	0.896	Y = 1.5950 - 0.0266IO + 0.0039DD - 0.0021GG
Dolly Varden Biomass	0.937	0.879	Y = 2.4749 - 0.0580AUS + 0.0819 VUS - 0.0091GG
Salmonid Biomass	0.907	0.823	Y = 3.5103 - 0.0546AUS - 0.0107GG + 0.0495VUS
All Streams Combined, N=18			
Coho Biomass	0.775	0.602	Y = 0.1939 + 0.0022ARV + 0.0106FDR - 0.0191ASU - 0.0069IO - 0.0012EE + 0.0145IX
Dolly Varden Biomass	0.874	0.765	Y = -0.0067 + 0.0118ARV - 0.0137DUB - 0.0313VP + 0.1024VEL - 0.0102GG + 0.0230FCR
Salmonid Biomass	0.942	0.888	Y = 0.6324 + 0.0152ARV - 0.0074TAREA + 0.0656FDR - 0.0106DUB + 0.0396FCR + 0.0558VEL

Independent Variables Used: TAREA, ARIF, AGLI, VP, VSU, ASU, AUS, ARV, DUB, CC, DD, EE, FF, GG, IO, GR, DEP, VEL, WID, FDR, FCR, FDP, IX, DISC

Table 10. Predictive equations of coho, Dolly Varden, salmonid biomass in logged and unlogged streams omitting variables FDP, FCR, and FDR and including date of sample. (See Table 5 for explanation of variables.)

Dependant Variable = Biomass	R	R^2	Predictive Equation
<u>Logged Streams</u>, N=9			
Coho Biomass	0.964	0.931	Y = -4.7614 + 0.0048ARV + 0.0814IX - 0.0039WID
Dolly Varden Biomass	0.924	0.854	Y = 2.1642 + 0.0161AGLI - 0.0729VUS + 0.0044FF
Salmonid Biomass	0.959	0.921	Y = 2.7527 + 0.0182AGLI - 0.0756VUS + 0.0051FF
<u>Unlogged Streams</u>, N=9			
Coho Biomass	0.946	0.896	Y = 1.5950 - 0.0266IO + 0.0039DD - 0.0021GG
Dolly Varden Biomass	0.937	0.879	Y = 2.4749 - 0.0580AUS + 0.0819 VUS - 0.0091GG
Salmonid Biomass	0.947	0.898	Y = 4.4205 - 0.0409AUS - 0.0108GG - 0.0340DAY
<u>All Streams Combined</u>, N=18			
Coho Biomass	0.729	0.532	Y = 0.9928 + 0.0014FF + 0.0021ARV - 0.0179VSU - 0.1067GR + 0.0023GG - 0.0010TAREA
Dolly Varden Biomass	0.874	0.764	Y = 2.753 + 0.0128ARV - 0.0109DUB - 0.0280VP - 0.0078WID + 0.0626VEL - 0.0070GG
Salmonid Biomass	0.909	0.828	Y = 2.153 + 0.0179ARV - 0.0453VP - 0.0157WID + 0.0799VUS + 0.0720VEL - 0.0869VSU

Independent Variables Used: TAREA, ARIF, VP, VSU, VUS, ASU, AUS, ARV, DUB, CC, DD, EE, FF, GG, IO, GR, DEP, VEL, WID, IX, DISC, DAY

Table 11. Predictive equation of the percent composition of juvenile coho in logged and unlogged streams.

Dependant Variable = SS Comp.	R	R^2	Predictive Equation
Logged Stream, N=9			
Coho Percent Composition	0.979	0.960	Y = 16.9851 + 1.9040VP - 0.6425DD - 0.4451CC
Unlogged Stream, N=9			
Coho Percent Composition	0.953	0.909	Y = 21.8760 + 0.3184DUB + 0.4028GG - 1.8976VEL
All Streams Combined, N=18			
Coho Percent Composition	0.934	0.873	Y = 82.4107 + 0.4208GG - 2.3766VEL + 0.2097DUB + 2.079IX - 0.7428ASU + 0.359EE

Independant Variables Used: TAREA, ARIF, AGLI, VP, VSU, VUS, ASU, AUS, ARV, DUB, CC, DD, EE, FF, GG, IO, GR, DEP, VEL, WID, IX, DISC, DAY

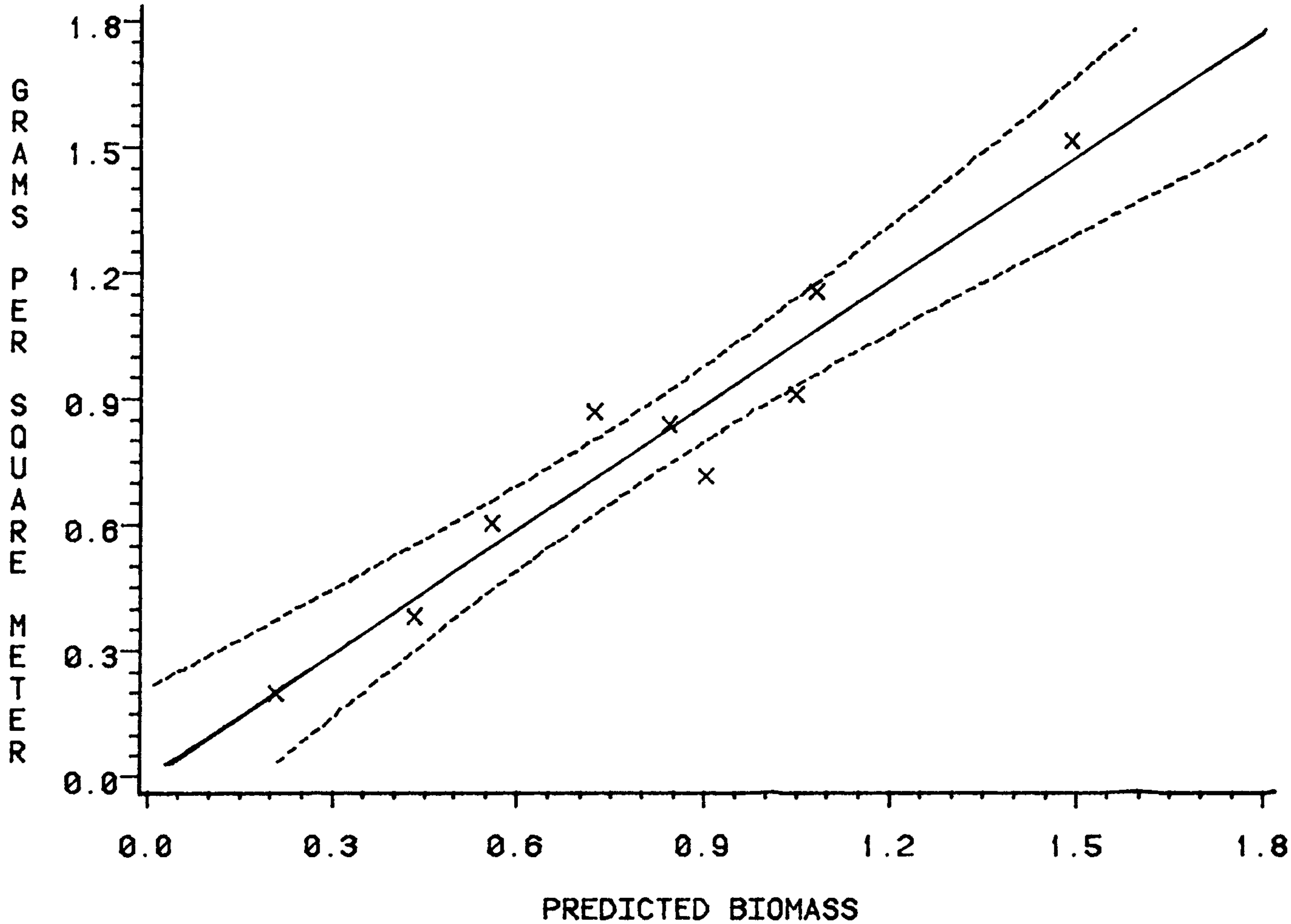

FIGURE 2. RELATIONSHIP OF OBSERVED BIOMASS TO PREDICTED BIOMASS OF COHO IN LOGGED STREAMS.

$$Y = + 0.0048ARV + 0.0814IX - 0.0039WID - 4.7614$$

R-SQUARED = 0.93

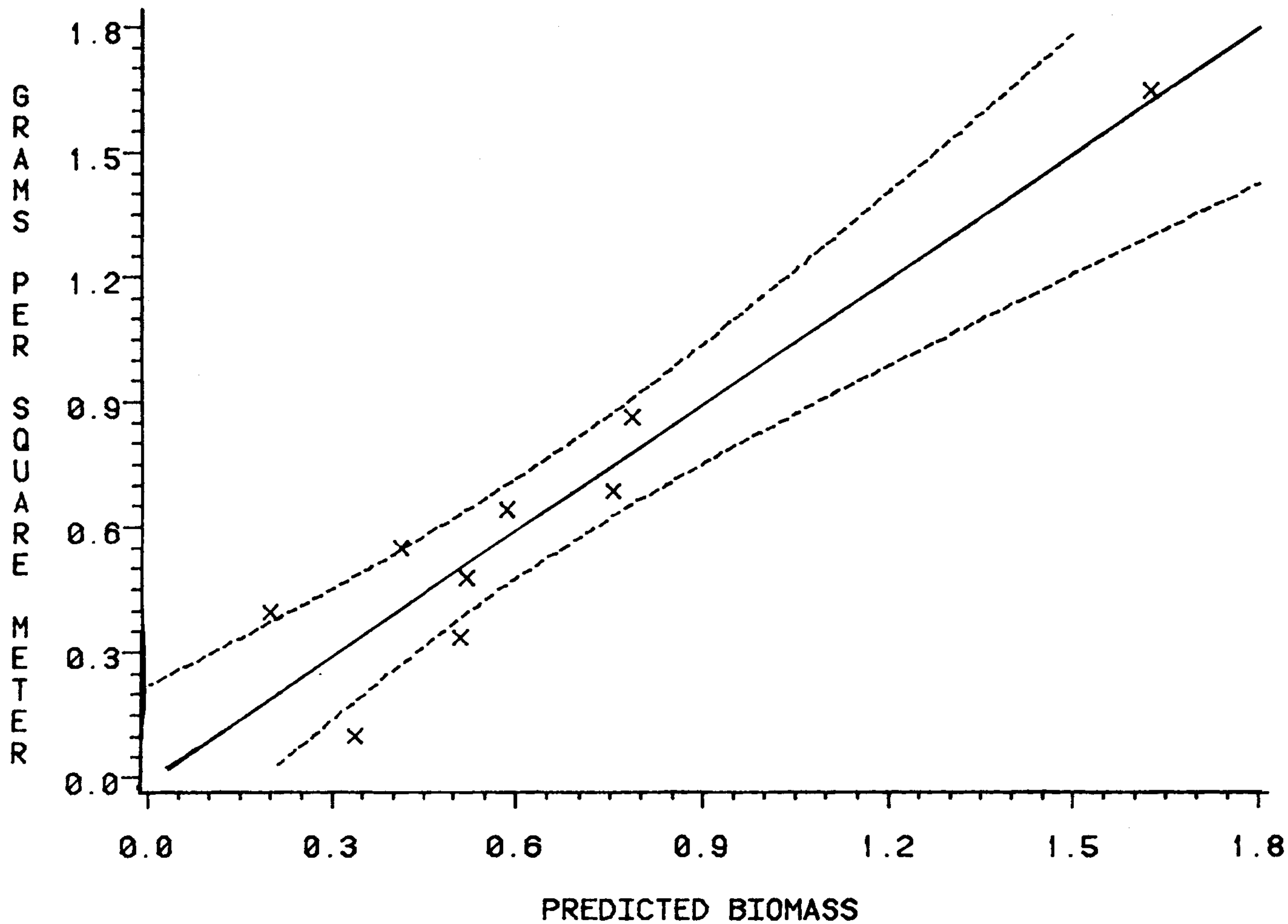

FIGURE 3. RELATIONSHIP OF OBSERVED BIOMASS TO PREDICTED BIOMASS OF COHO IN UNLOGGED STREAMS.

Y= - 0.0266IO + 0.0039DD - 0.0021GG + 1.595

R-SQUARED = 0.90

Table 12. Population statistics for 10 unlogged (Kadashan-Halleck Falls) and 10 logged streams (Fog-Halleck). Halleck Falls and Kawasaki Creeks were removed from the analysis but are shown here for comparison.

NAME	CODE	COHO BIOMASS	COHO DENSITY	CONDITION FACTOR	DV BIOMASS	DV DENSITY	CONDITION FACTOR	TOTAL BIOMASS	TOTAL DENSITY
KADASHAN	15	0.47697	0.15287	0.0112102	3.67520	0.824036	0.0111140	4.15217	0.97691
INDIAN	13	0.54940	0.14889	0.0112570	0.86680	0.148171	0.0114429	1.41620	0.29706
SAGAN	11	1.64655	0.37678	0.0106541	1.36188	0.188365	0.0092848	3.00843	0.56515
SLICK	14	0.63958	0.18222	0.0102860	0.04719	0.008903	0.0038753	0.68677	0.19112
NBAYU	16	0.86327	0.16197	0.0107288	0.57786	0.076639	0.0115136	1.44113	0.23860
NOFISH	18	0.39422	0.08879	0.0106133	1.18737	0.242816	0.0099786	1.58159	0.33160
CATHY	12	0.68425	0.15239	0.0119895	0.82952	0.207900	0.0097552	1.51377	0.36029
HONDA	19	0.33522	0.10443	0.0112163	0.08959	0.029666	0.0086333	0.42481	0.13410
STEEP	20	0.10051	0.01416	0.0114921	2.05949	0.348476	0.0095558	2.16000	0.36263
HALLECKF	17	0.40675	0.10093	0.0123318	0.25996	0.037404	0.0112334	0.66671	0.13834
FOG	51	0.19929	0.05490	0.0101422	2.44482	0.636672	0.0097066	2.64411	0.69157
STARR	52	0.90948	0.17031	0.0115388	7.06187	0.737917	0.0116629	7.97134	0.90823
DEADCAT	54	0.38107	0.08248	0.0107009	1.76421	0.249889	0.0115858	2.14529	0.33237
NBAYC	57	0.60356	0.16627	0.0085428	1.06888	0.110421	0.0097500	1.67244	0.27669
SEALBAY	53	1.51846	0.41602	0.0113410	2.40630	0.367374	0.0089789	3.92475	0.78339
GIRDLE	58	1.15684	0.28706	0.0116591	2.62111	0.399560	0.0111354	3.77795	0.68662
KAWA	56	3.99322	1.52997	0.0087286	1.59044	0.210655	0.0089550	5.58366	1.74062
LAZYBEAR	60	0.86839	0.22792	0.0110889	0.44585	0.019234	0.0070927	1.31424	0.24716
NOAH	55	0.84033	0.23805	0.0095607	1.09368	0.159894	0.0093609	1.93400	0.39795
HALLECK	59	0.71441	0.15200	0.0113987	0.51922	0.058735	0.0094588	1.23363	0.21074

g/m^2), with densities of $0.05/m^2$-$1.5/m^2$ as was Dolly Varden biomass (0.51 g/m^2-7.0 g/m^2), with densities of $0.05/m^2$-$0.73/m^2$.

Total salmonid biomass in unlogged streams ranged from 0.42 g/m^2-4.1 g/m^2, with corresponding densities of $0.134/m^2$-$0.976/m^2$. In logged streams, salmonid biomass ranged from 1.2 g/m^2-7.9 g/m^2, with densities of $0.21/m^2$-$1.7/m^2$.

Condition factors of both species were similar in logged and unlogged streams.

We used three methods to compare biomass in the logged and unlogged streams: 1) t-tests between the means of logged and unlogged biomass, 2) paired t-tests of biomass with streams paired by discharge, gradient, total surface area, date, and proximity, and 3) analysis of covariance that test the group biomass means after having been adjusted by the habitat values within each group.

Tests between Group Means:

T-tests showed that the numbers of Dolly Varden and coho were not significantly different in the logged and unlogged groups (Table 13). When the species were combined and presented as a total salmonid number, there was a significant difference at $P<0.05$ between logged and unlogged watersheds. This, however, does not mean that production is greater, as the population may not have equivalent mean weights or have the same density. This is apparent in tests of biomass. Biomass of coho, Dolly Varden, and total salmonids was not significantly different ($P<0.05$) in logged and unlogged streams. Additionally, none of the other fish parameters, mean weight, mean length, or catch, were significantly different.

T-tests by Paired Comparison:

We ranked the biomass of each logged stream with the biomass of unlogged streams by discharge, gradient, total area, and by the date and proximity (Table 14) and performed paired t-tests on each group. The results (Table 15) show that there were no significant difference ($P<0.05$) between the pairs with the exception of the NDV paired by date. Note that all 20 streams were used in these tests, as extreme cases, e.g., Kawasaki Creek and Halleck Falls Creek, could be grouped as a related pair in respect to discharge.

Analysis of Covariance:

The adjusted mean biomass of coho, Dolly Varden, and total salmonids (dependent variable) were compared in logged and unlogged streams using analysis of covariance (Table 16). For independent variables, we chose habitat parameters that were least likely to be influenced by timber harvest. These variables were gradient, discharge, and surface area. Using these variables, the test found no significant differences ($P<0.05$) in biomass of coho, Dolly Varden, or total salmonids between logged and unlogged sample streams.

Table 13. T-tests of logged and unlogged fish parameters (logged, N=9; unlogged N=9).

	Clearcut		Uncut		t-Test
Parameter	Mean	S.D.	Mean	S.D.	P>|t|
NDV	171.128	142.844	88.900	68.245	0.14
NSS	132.649	80.897	74.452	45.361	0.08
N	303.778	177.456	163.352	68.527	0.05
DVBIO	2.158	2.015	1.188	1.123	0.23
SSBIO	0.799	0.394	0.632	0.439	0.40
BIOMASS	2.958	2.118	1.821	1.154	0.18
SSCOMP	47.853	27.123	49.613	30.275	0.89
DVCOMP	52.147	27.123	50.387	30.275	0.89
TDV	125.333	105.514	64.222	47.749	0.14
TSS	93.889	65.936	55.556	27.409	0.13
T	219.222	138.092	119.778	38.758	0.06
WDV	9.124	5.576	5.354	1.465	0.08
WSS	4.104	0.635	4.362	1.250	0.59
FLDV	95.740	21.282	83.588	12.387	0.16
FLSS	72.670	3.035	72.840	6.404	0.94

Table 14. Logged and unlogged streams paired by Discharge, Gradient, Area, and Date/Proximity; used for Paired Comparison T-tests.

Pair No.	Discharge		Gradient		Total Area		Date and Proximity	
	Logged	Unlogged	Logged	Unlogged	Logged	Unlogged	Logged	Unlogged
1	Fog	No Fish	Fog	Steep	Fog	Kadashan	Slick	Seal
2	Seal	Catherine	Noah	Halleck F.	Girdle	Sagan	Kadashan	Fog
3	Girdle	Kadashan	Halleck	Dadashan	Starr	Catherine	Catherine	Lazy Bear
4	Starr	Honda	Girdle	Slick	N. Bay L.	Steep	Sagan	Dead Cat
5	Dead Cat	N. Bay U.	Lazy Bear	Indian	Seal Bay	No Fish	Girdle	No Fish
6	N. Bay L.	Slick	N. Bay L.	Sagan	Dead Cat	Honda	Steep	Noah
7	Halleck	Sagan	Starr	Catherine	Noah	Slick	Honda	Kawasaki
8	Noah	Indian	Kawasaki	N. Bay U.	Halleck	N. Bay U.	N. Bay L.	N. Bay U.
9	Lazy Bear	Steep	Seal Bay	Honda	Lazy Bear	Indian	Halleck F.	Halleck 04
10	Kawasaki	Halleck F.	Dead Cat	No Fish	Kawasaki	Halleck F.	Starr	Indian

Table 15. T-tests of the mean difference between logged and unlogged biomass paired by discharge, gradient, area, and date of sample.

Test	Mean Diff.	S.E. Mean Diff.	T	P>|T|
<u>Paired by Discharge</u>:				
NDV	94.4	51.4	1.84	0.0996
NSS	218.0	162.3	1.34	0.2121
DVBiomass	1.00	0.75	1.33	0.2152
SSBiomass	0.50	0.38	1.31	0.2228
<u>Paired by Gradient</u>:				
NDV	94.4	56.7	1.67	0.1300
NSS	218.0	159.5	1.37	0.2049
DVBiomass	1.00	0.76	1.31	0.2228
SSBiomass	0.50	0.33	1.50	0.1683
<u>Paired by Area</u>:				
NDV	94.4	52.4	1.80	0.1050
NSS	218.0	161.9	1.35	0.2111
DVBiomass	1.00	0.66	1.51	0.1661
SSBiomass	.50	0.37	1.37	0.2045
<u>Paired by Date</u>:				
NDV	94.4	40.9	2.31	0.0466
NSS	218.0	167.5	1.30	0.2255
DVBiomass	1.00	0.65	1.55	0.1563
SSBiomass	.50	0.36	1.39	0.1990

Table 16. Analysis of covariance of Dolly Varden biomass, coho biomass, and coho salmonid biomass in 9 logged and 9 unlogged streams. Covariance on discharge, gradient, and surface area.

Test	Group	N	Group Mean	Adj. Group Mean	S.E.	Analysis of Variance Statistics	
						F-Value	Prob. (Tail)
DV Biomass	Uncut	9	1.1832	0.8565	0.623	2.9161	0.1115
	Clearcut	9	2.1584	2.4902	0.623	...	...
Coho Biomass	Uncut	9	0.6322	0.6355	0.156	0.4324	0.5223
	Clearcut	9	0.7990	0.7947	0.156	...	...
Total Biomass	Uncut	9	1.8205	1.4930	0.657	3.1518	0.0992
	Clearcut	9	2.9575	3.2849	0.657	...	...

Overwinter Survival

Thermographs will not be removed from the study sites until May, 1983. Data from the instruments will be prepared and presented in the 1984 Annual Report of Performance.

Summary

We found no significant difference in biomass of juvenile coho, Dolly Varden, and total salmonids in logged and unlogged areas. There were fewer undercut banks, a preferred coho habitat, in logged streams, but the growth of streamside vegetation may have supplanted this loss. The association of salmonid biomass with different forms of habitat in logged and unlogged streams suggests that fish can be very flexible in their habitat preference without suffering a loss in standing crop. This leads us to conclude that long term gradual changes in habitat resulting from a decrease in large debris input as postulated by researchers (Chamberlin, 1982) may not have occurred yet. Negative influences on stream habitat, if they occur, may not be strong enough after 20 years to override the adaptability of juvenile coho and Dolly Varden.

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ACKNOWLEDGEMENTS

The author would like to thank Randy Erickson, Lee Neimark, Rick Sinnott, Tom Faverty, Randy Kacyon, and Ted Whitesell for their expert job in collecting the data used in this report.

STREAM SURVEY SUMMARIES

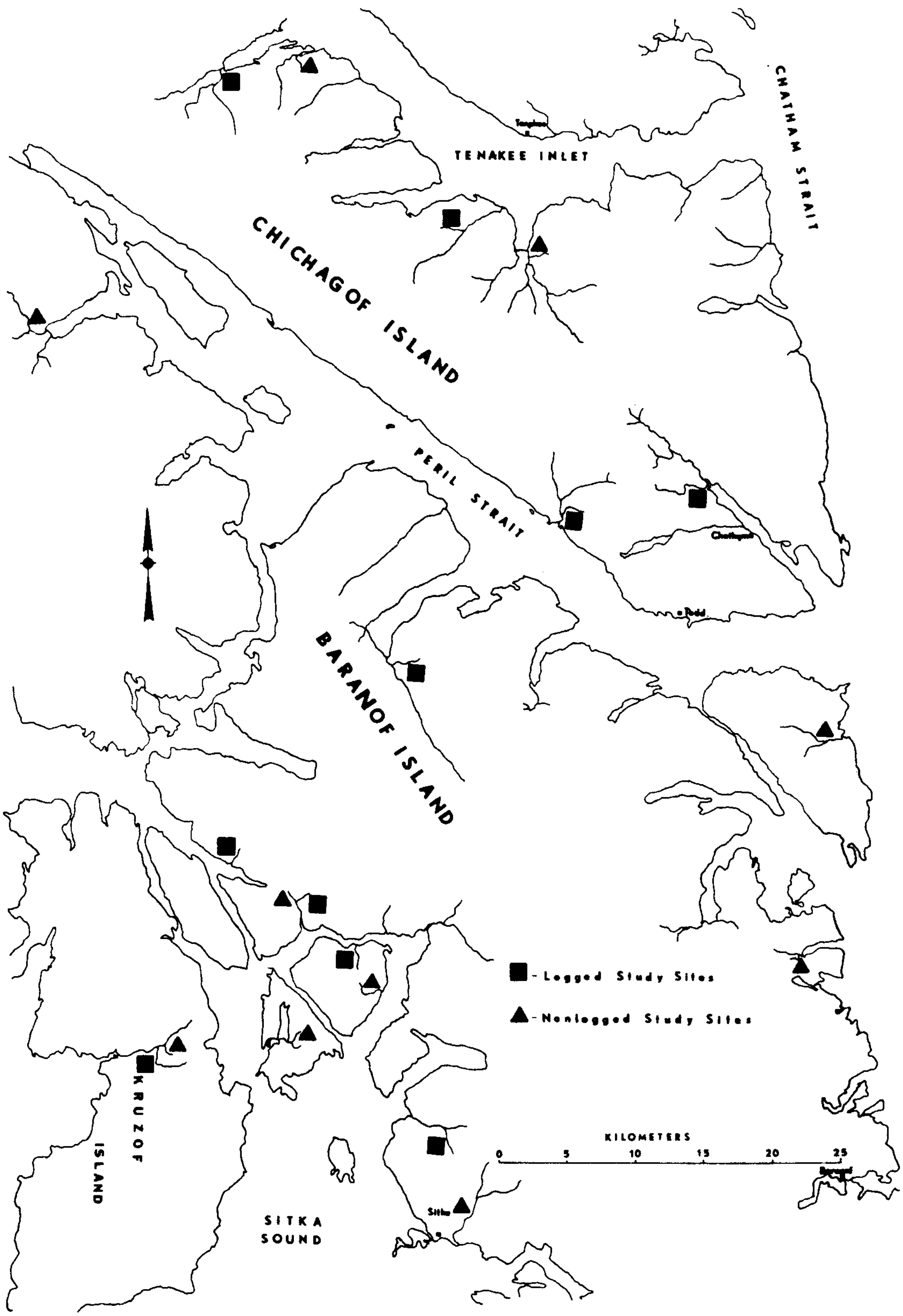

Figure 1. Distribution of 10 logged and 10 unlogged study sites on Baranof and Chichagof Islands, southeast Alaska.

STREAM SURVEY SUMMARY

STREAM: "Kadashan Creek"
LOCATION: Kadashan Bay, Tenakee Inlet

MAP REFERENCE: Sitka C-4 LATITUDE: 57° 42' N LONGITUDE: 135° 13' W
TRIBUTARY TO: Kadashan River 112-42-10250 MAIN DRAINAGE: Same
ORIGIN: 1st & 2nd order run off streams
LENGTH: 1 mile, 1.5 km WATERSHED AREA: SE Sec. 16, SW Sec. 15

1. FLOW: $0.006 m^3/sec$
   RANGE: 83 gals/sec VELOCITY: Sluggish AVG. WIDTH: 89.2 cm
   AVG. DEPTH: 6.47 cm
   FLOOD HEIGHT: COLOR/TURBIDITY: Clear/Clear

2. ACCESSIBILITY: Float plane to mouth of Kadashan R., then walk upstream to USFS cabins - next to cabins

3. ACCESS STATUS: No road access

4. SECTION SURVEYED: Lower ¼ mile
   TRIBUTARIES: 1st & 2nd order

5. BOTTOM TYPE: 9% Detritus, 8% Sand, 4% Fine gravel, 72% Coarse gravel, 7% Rubble
   STREAM GRADIENT: Lower 300 m 1.9%

6. POOLS-DESCRIPTION & FREQUENCY: Size 2, Type 2, Frequency 3; all pools less than 2 feet deep - probably not sufficient for overwintering fingerlings

7. BARRIERS: None

8. SPAWNING AREA: Pinks & dog salmon in Kadashan R. but not seen in the Creek

9. BANK COVER: Intensely shaded by spruce/hemlock, rusty menziesia

10. WATERSHED TYPE: Wooded

11. FISH SPECIES: Dolly Varden, coho, slimy sculpin

12. FISHING HISTORY: Rearing stream - no fishable populations

13. FISHING INTENSITY: None

14. INVERTEBRATES: ABUNDANCE:

15. AQUATIC VEGETATION: Sparse algae

16. WATER USE: None

17. POLLUTION: None

18. REMARKS:

BY: Rick Sinnott DATE: July 8-10, 1982

SPORT FISH - LAND USE PROJECT
STREAM SURVEY

Quad Map:	Sitka C-4	Stream:	"Kadashan Creek"
Tributary to:	112-42-025	Loc:	Kadashan Bay, Tenakee Inlet
		Date:	July 8-10, 1982

Water Quality

D.O.:	11 mg/L	Temp.:	8.0°C
Conductivity:	46 umho	Alkalinity:	24.5 mg/L
Total Hardness:	30 mg/L	Calcium Hard.:	28 mg/L
		pH:	6.9

Morphology

Mean Discharge:	0.006 m^3/s	Mean Gradient:	1.9%
Surface Area/300m reach:	275.1 m^2	Pool volume/300m:	14.29 m^3

Fish

Dolly Varden Juveniles

Density (no./m^2): 0.83
Biomass (g/m^2): 3.67

Age	Mean Fork Length	Mean Weight
0		
I		
II		
III		
IV		
V		
$\bar{x}$		

Coho Salmon Juveniles

Density (no./m^2): 0.15
Biomass (g/m^2): 0.47

Age	Mean Fork Length	Mean Weight
0		
I		
II		
III		
$\bar{x}$		

No. Other Species Caught

None

"KADASHAN CREEK"
(Unlogged)

July 8-10, 1982

Location of Stream: Kadashan Bay, Tenakee Inlet, Chichagof Island. The tributary enters Kadashan River (112-42-025) from the east, passing just north of the U.S. Forest Service cabins. Confluence is near the south boundary of Section 16.

Location of Reach: Beginning just above a short area of alder influence, approximately 40 m from edge of meadow. The beginning is roughly 100 m from confluence with Kadashan River.

Description: Relatively stable flow; stream flow was approximately the same on May 27 (with snow still melting), between July 8-10 (just as prolonged drought ended), and on August 25 (after long rainy period) when we took photos. Section 2 is a 3rd order stream; above is 2nd order. The old growth forest was relatively open canopy above the stream.

Chum and pink salmon were abundant in the Kadashan River but were not spawning between July 8-10. They had just begun to pass the weir on July 8. By August 25, most chum salmon were dead and many pinks were also spawned out.

Aerial Photo <: 02220 376 310
02220 376 311

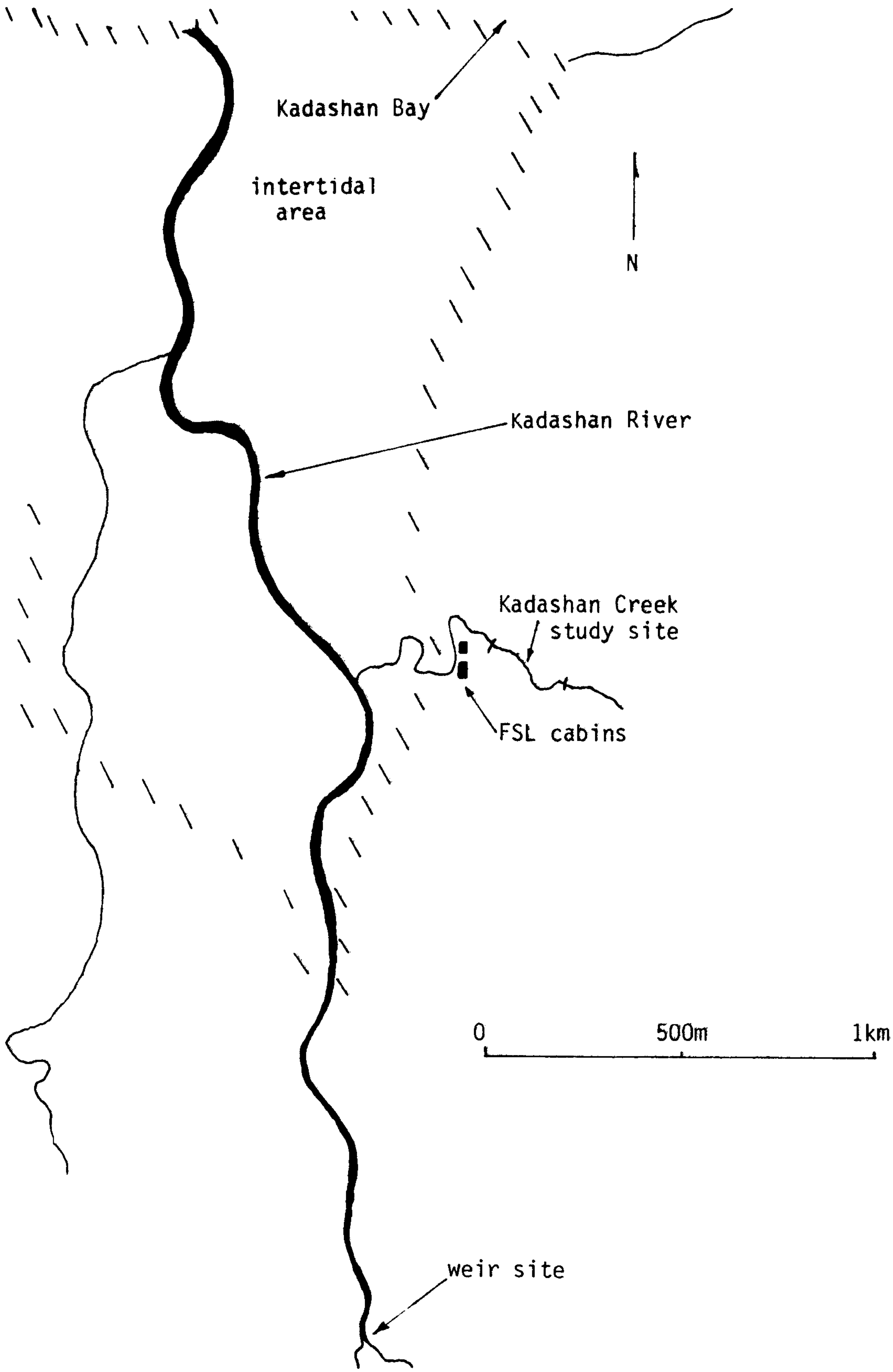

Figure 2. Kad.shan study site.

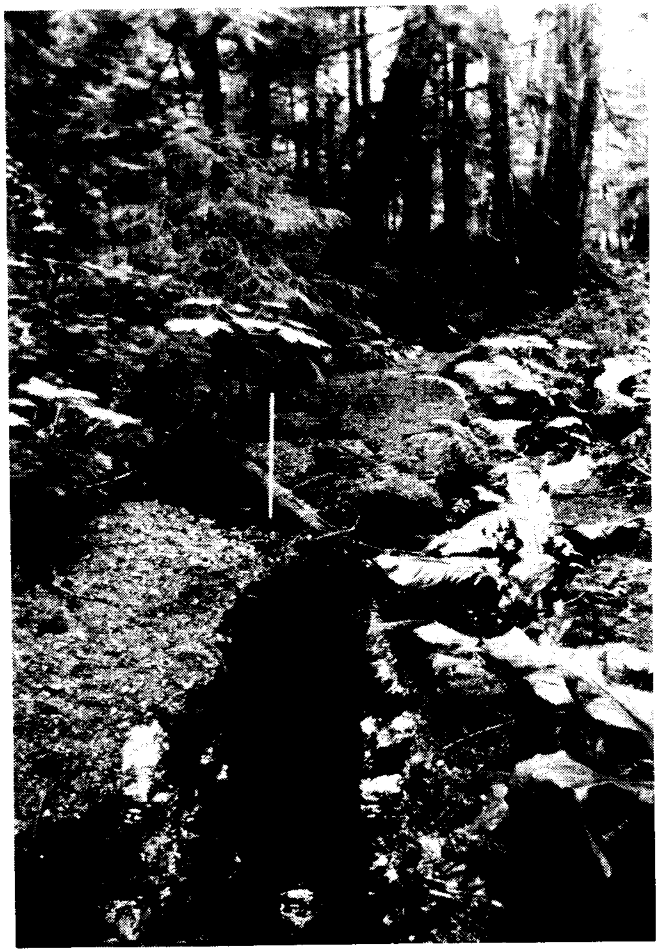

Figure 3. Kadashan Creek, showing section 2.

Figure 4. Kadashan Creek, showing section 4.

Figure 5. Kadashan Creek, showing section 7.

Figure 6. Kadashan Creek, showing section 10.